Beer recovery today

A review of modern technology

Following a *Brewer and Distiller* article published in 2006, Paul Buttrick's review of beer recovery from tank bottoms went on to became the reference work most quoted in IBD examination scripts around the world. Here we catch up with technology six years later.

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In the days before 'duty at the gate', most breweries had some sort of recovery system to reduce duty-paid beer losses. With breweries becoming larger and waste disposal costs increasing, recovering high quality beer from yeast is again becoming a real topic for debate.

Beer recovery in traditional British breweries often involved the Scott yeast press system. In this process, yeast was skimmed by vacuum from the top of an open fermenter to a tank usually in a room below the fermenting room. The tank was then pressurised with air and the yeast slurry passed over a yeast press, where high value beer (excise paid) was recovered and returned to the fermentation vessel it came from. Pressed yeast (of about 25% dry weight solids) was either used for repitching or sold to a well known yeast extract manufacturer. However, the plant was difficult to clean, which resulted in a serious microbiological risk and many breweries stopped returning beer because of this.

With the advent of processed beers, lagers, and small pack beers, additional technology was used to improve the quality of the recovered beer. Beer was sometimes filtered and flash pasteurised before being returned occasionally to the fermentation vessel but more often to the cold store tank.

Figure 1: A one tonne yeast press in a British brewery with polypropylene plates and frames installed in the 1980s.

Figure 2: A 44-tonne tanker delivering 28 tonnes of yeast to a pig farm in the UK.
Photo: Wheyfeeds Ltd.

Even though the risk of microbiological contamination was significantly reduced, there were problems with high beer oxygen levels, which coupled with high pasteurisation time and temperatures, made the beer taste poor and had a negative impact on flavour stability, haze stability and beer foam. Despite the pasteurisation process, cleaning and sterilisation of the equipment continued to give problems; this area of the brewery was often away from mainstream production areas and consequently did not always get the attention required to maintain quality standards. As breweries became larger, running costs continued to rise and the complexity of the operation increased.

What happened next?

The financial driver for recovering beer increased as beer duty rose significantly above the rate of inflation. Rotary vacuum filters, open mud discharge (OMD) filters, and large semi-automated presses (Figure1) were installed which were able to handle increased volumes. A pressure squeeze from membrane presses increased beer recovery rates further.

Both the rotary vacuum filter and OMD filter needed a filter aid to recover the beer, which also had high oxygen content and any powder residues were not welcomed by food producers. These investment returns certainly kept the accountants happy, but were not good for beer flavour and quality.

Where are we now?

Despite the move to 'duty at the gate' and the value of recovered beer reducing from approx £106/hl (including duty at 5%ABV at current UK rates) to £10–12/hl, some breweries are still using presses to recover beer, but problems with beer quality, running cost and complexity have encouraged them to look at alternative technologies.

Prior to 2006, few breweries outside the UK recovered beer from surplus yeast mainly because returns on investment were poor and the probably correct perception that beer quality would be compromised.

Co-product not a waste product

The tables opposite show approximate operational savings that can be made by recovering beer from surplus yeast. The figures are for indication only, and each brewery will have to use its own data and costing conventions to get a more accurate value.

Although beer savings alone may not

justify a beer recovery project, the costs associated with effluent and disposal cost for yeast slurry will play an increasing part in the financial equation. As disposal sites become full and costs increase with environmental levies, breweries will be driven even more to reduce their 'waste'.

Companies now look at surplus yeast as a co-product producing an income stream instead of a 'waste' stream with a disposal 'on-cost'. With food safety being high on the agenda, farmers are looking more at accredited food sources. Brewers' yeast is an ideal high protein food for pigs for example.

It does, however, have to compete with other feed, and can only be economic if slurries are concentrated before collection. As a basic rule of thumb, yeast slurry from fermentation vessels is about 10% dry weight (dw), from cold storage tanks approx 7% dw, and a positive cash flow is only available with slurries above 14% dw. Depending on circumstances, revenue of approx £1/%/tonne above14% dw, so yeast slurry despatched at 17% dw would attract gross income of £3/tonne.

It is important to note that yeast sent for animal feed has to be dead before it is consumed – this means that either the brewer or the feed supplier will have to kill the yeast using heat or chemical addition. Because of the high cost of transport, slurry sent out at less than 14% dw is likely to incur a transport on-cost. (Figure 2)

What should a brewer's approach be now?

With costs being squeezed, brewers are being driven to reduce beer losses. Consolidation of brewing plants with increased capacity makes beer recovery more financially attractive and most companies are grappling with the 'how are we going to reduce our losses and waste costs?' question.

The answers are not straight forward; even different plants within the same group have come up with different solutions. Another significant factor is that those breweries which already had established beer recovery facilities have great difficulty in upgrading to higher quality, more efficient operations, because what they already have makes a considerable impact on their costs and extra investment based on a straight Return On Capital Employed is difficult to justify. From my experience, the question of what equipment and process to use will depend very much on what equipment already exists, the quality standards expected, and what level of investment can be justified.

What are the options?

There are a number of options and technologies available:

Do nothing

Some brewers may decide that they do not want to return any recovered beer for quality reasons. These breweries will increasingly have to address the problem of where and how their surplus yeast will be disposed of in the future. They may decide to concentrate surplus yeast but not return recovered beer to their beer stream.

Continue with existing press operations

This may be possible for a time, but control of quality and maintaining aging equipment will eventually prove to be uneconomical and unacceptable from a quality perspective. The beer yield from presses is high, with yeast being concentrated to approx. 25% dw.

Alcohol recovery from yeast slurries

Some UK brewers recovered alcohol from surplus yeast by evaporation back in the 80s and 90s, and some continue to get good return for their efforts. GEA-Wiegand (Figure 3) and Bucher-Unipektin were the main suppliers of this equipment. The same technology, based on falling film evaporation working at 60–70°C and reduced pressure, could also be used for producing alcohol free beers. The yield is high (up to 94%) because alcohol is recovered from within the yeast cell as well as from the beer slurry. With good plant maintenance and carbon filtration of the distillate, there are positive quality aspects of this process. The distillate is biologically stable and has little effect on flavour, head retention and haze stability. Because the flavour is neutral, alcohol distilled from different brands need

Table 1: approximate volumes of waste yeast and recovered beer expected from different sized breweries, and the value of the recovered beer.

Volume brewed khl	Surplus yeast/bottoms khl	Volume of beer recovered (65%) khl	Volume of yeast for disposal (35%) khl	Value (£) of recovered beer (£10/hl)
500	20	13	7	130k
1000	40	26	14	260k
2000	80	52	28	520k

The calculations are based on: Surplus yeast is 4% of site volume; the beer recovery rate from the yeast is 65%, leaving 35% surplus yeast; recovered beer is valued at £10hl.

Table 2: the calculated operational cost saving (including beer) if waste is sold as a "co-product" at £3/tonne as opposed to a "waste" product with disposal costs of £3/tonne.

Volume of beer brewed khl	Operational saving (beer and disposal cost) £k
500	£211
1000	£422
2000	£844

Table 3: shows the same calculation if waste disposal costs increase to £6 a tonne

Volume of beer brewed khl	Operational saving (beer and disposal cost) £k
500	£271
1000	£542
2000	£1,084

Figure 3: Falling-film evaporation plant for the dealcoholisation of beer.
Photo: GEA-Wiegand.

Figure 4: Westfalia GCF-465 Decanter Separator.

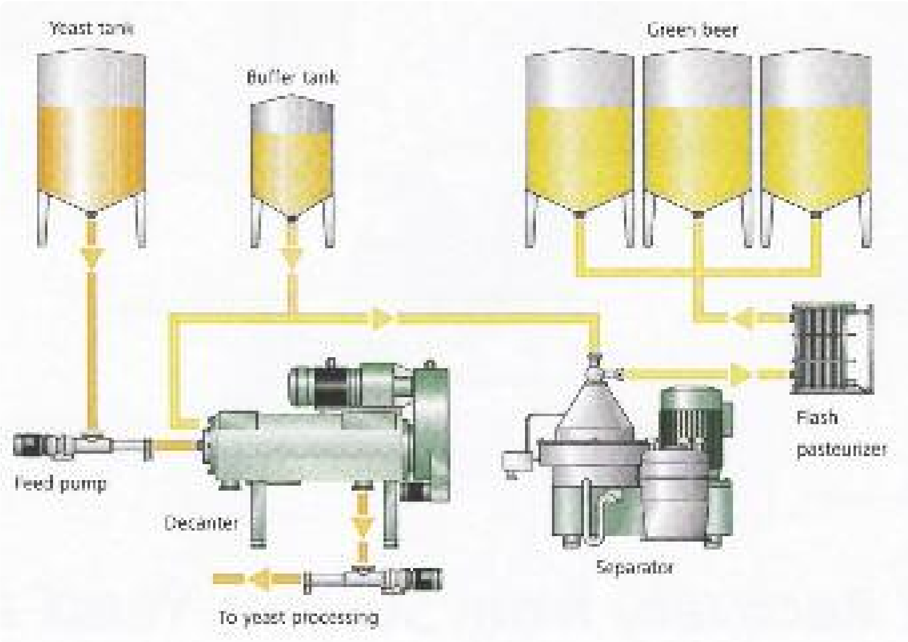

Figure 5: Process diagram for decanter separator/polishing separator for beer recovery from yeast. *Image: GEA-Westfalia.*

not necessarily be segregated and can be returned to beer on transfer to cold storage tank. A downside for this technology is the image of 'chemical' brewing, particularly when premium brands are involved.

Centrifuges

There are a number of options where a centrifuge (or separator) can be used to recover beer from surplus yeast. These can be split into two main types of operation:

Decanter centrifuges

These machines have been improved in recent years to being more suitable for foodstuffs, and are in use in a number of large breweries. There have been issues with cleanliness and sterility and manufactures say that these have been overcome. Due to their mode of operation, these machines are able to concentrate yeast slurries up to 25% dw. (Figure 4)

The 'squeezing' element from the decanter screw is thought by some to cause damage to the yeast cells. The centrate does have high yeast counts and some brewers have a secondary clarification process (such as a smaller 'polishing' centrifuge) and flash pasteuriser in line after the main decanter centrifuge, to ensure quality is assured before beer is returned. (Figure 5)

The cost of a single decanter centrifuge may be attractive, but the extra equipment needed to ensure quality, increases cost and complexity considerably. Some brewers might decide that centrate with a high yeast count does not have a deleterious effect on quality, and therefore if cleanliness and sterility can be assured and the recovered beer can be blended back immediately, then extra equipment is unnecessary.

Another claimed advantage is the ability to handle a range of slurry thickness fed to it; the control system needs to be very good to ensure consistent centrate out of the machine.

Continuous discharging disk bowl nozzle centrifuges

Disk bowl and continuous discharging disk bowl nozzle centrifuges are sometimes considered for recovering beer from yeast slurries. Large disk bowl centrifuges are not often used and manufacturers more often recommend their decanter machines.

Continuous discharging disk bowl nozzle centrifuges (Figure 6) are compact hygienic machines that can be used to concentrate yeast slurries, e.g. of pitching yeast. In beer recovery situations they can also be used 'on- line' to concentrate yeast bottoms and simultaneously dose the centrate back into the main beer stream, or as 'off-line' stand alone machines.

These machines have the disadvantage that the yield is variable according to the thickness of slurry put to the machine. Compared to 25% dw yeast from a decanter centrifuge, the yeast from this machine will be about 18-22% dw. The yeast count in the centrate varies according to the thickness of slurry pre machine and control parameters applied.

Their advantage is that the machines are compact, easy to keep clean and sterile, and are not thought to cause undue stress to the yeast. If a brewer already had a yeast press achieving 25% dw yeast, then the yield from a continuous discharge bowl centrifuge would be less. However brewers who have no current beer recovery operation, would be attracted by the physical advantages of the machine as well as reducing their losses

Figure. 6: Alfa Laval BRUX 510 continuous discharge separator module.

Cross flow filtration

Cross flow filtration technology has been applied by a number of manufacturers. The main advantage of crossflow is, that due to the very small pore size of the membranes (typically 0.5-0.8 microns), the filtrate is close to bright beer quality, virtually yeast free, has good palate and physical parameters. There are two groups of materials used for manufacture of membranes, polymers (polysulphone, polypropylene) or ceramic (usually Al_2O_3). Installations can be completely automated. Recent trends have been towards the use of ceramic membranes for beer recovery systems. Despite being expensive they have a longer life than polymer equivalents (typically eight years against only two years) and are less prone to failure.

High flow rates are the driving force behind the beer/yeast separation and a heat exchanger is needed within the equipment to reduce yeast stress and prevent autolysis. These filters including Keraflux™, from Pall, and Cerinox™ from Filtrox, are based on robust ceramic membrane technology (Figure 7).

Because cross flow filters rely on the

pumping of yeast slurries around the membrane, the final thickness of the yeast is less than 20% dw at the end of a batch. In order to achieve an extract recovery equal to a yeast press of 25% dw, a 'diafiltration' with deaerated water can be used to 'wash out' additional beer from the slurry. Control parameters need to be set so that the 'diafiltration' process does not wash out any undesirable material from the yeast.

A recent development in membrane filtration technology is a plate and frame polymer based membrane from Alfa Laval (Figure 8). This equipment has 0.45 micron membranes and is designed to give low pressure conditions and keep energy consumption down. This type of filter concentrates yeast slurry to approx 20% dw, so yields are less than from some other plant alternatives, but used in conjunction with a decanter centrifuge yields and quality of recovered beer can be excellent.

An initial disadvantage of membrane systems has been the cost of replacement membranes. The manufacture of the membrane has improved significantly and the guaranteed life is now making this option more affordable.

Blending yeast slurry back pre-centrifuge

This process involves taking yeast from the bottom of a vessel and dosing it back as beer is transferred from a fermenting vessel via a continuous discharge disk bowl centrifuge to a maturation vessel/cold store tank. The proportional dosing of the tank bottoms means that the centrifuge will be able to remove the yeast dosed back because the load is spread over a large volume of beer.

This looks to be an ideal system – a simple'on-line' process with little extra equipment, especially if green beer centrifuges are already in use. However there are a number of considerations. The centrifuge must be sized to handle the extra yeast dosed from the vessel at the required beer transfer rate. If the centrifuge is not big enough to handle the extra yeast, then investing in extra green beer centrifuges can be very expensive (Figure 8). The dose back rate needs to be kept at low levels to reduce the possibility of yeasty flavours in the beer and planning within the brewery must be such that bottoms and beer transfer can be carried out simultaneously – this is not as easy as it sounds.

Blend-back rates?

For centrate from presses and centrifuges, most brewers put a 3 -5% limit on blending back. This is chosen because any flavour or quality differences will be blended away and not be noticed in the final beer; it also happens to be approximately the overall rate at which filtrate is produced. With crossflow technology, producing bright filtrate, brewers have blended back at up to 10%. With alcohol blend back, the maximum can sometimes be set by local excise authorities and (in the UK) is approx 2–3% depending on the strength of the beer.

Where to blend-back?

This is determined by the quality of filtrate/centrate and policy of the brewer. Some brewers add beer back to the whirlpool or into the wort stream just before wort cooling. This can be successful as long as there is no yeast in the filtrate which will be autolysed by the hot conditions. The hot environment also has a pasteurising effect. This type of operation is not as straight forward as it seems, because recovered beer is not always produced in sync with brewing.

Options for centrate with higher yeast counts include being added to actively fermenting yeast in fermenter, where the purging effect of fermentation washes out any flavour defects. Most brewers add beer back between fermenter and cold storage tank and some add beer from crossflow equipment to beer before filtration.

There is an old brewer's 'rule' which says that any addition to a beer should be made going forward in the process; the benefit here is that any quality issues are restricted to beer from the point off addition. When adding returned beer just before filtration, care must be taken to ensure that there are no issues with haze stability.

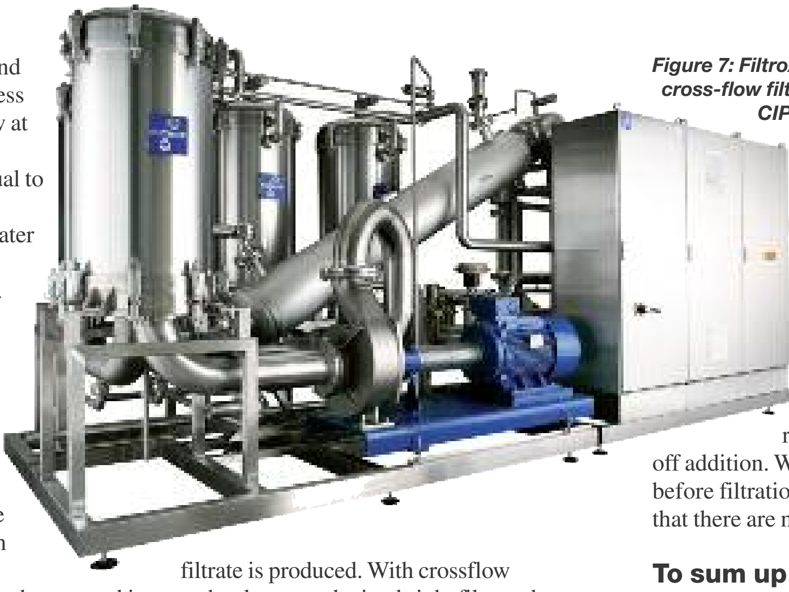

Figure 7: Filtrox CERINOXTM BR ceramic cross-flow filter unit, showing filter unit and CIP station.

To sum up

Recovery of beer from tank bottoms can be justified, with spent yeast from a recovery process considered as a co- product with value instead of a 'waste' on-cost. There are numerous alternative technologies for recovering beer from bottoms. Each brewery needs to assess its own quality and operational requirements before deciding what is best for them. There is no ideal solution which can be universally recommended and applied.

Finally, a word about total investment costs. The justification for installing beer recovery equipment can easily be made on the basis of a single piece of recovery equipment. However, the associated plant can increase the overall project cost at least twice and brewers need to be very clever in identifying the minimum practical cost of this plant in order to justify their investment.

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Figure 8: Alfa Laval cross-flow system for beer recovery installed at the Monchengladbach Brewery, features purpose-designed Alfa Laval microfiltration membranes, mounted in the Alfa Laval M39H plate-and-frame module.